

# Assignment 1

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- 1.1. The most central idea in system thinking is to consider how all important parts work together, not individually, and ignores details that do not matter.
- 1.2. P'. Problem is that the inventory of finished goods has declined steadily, it is important because due to insufficient number of finished goods demand exceeds supply.  
H. In terms of model structure inventory of finished goods is stock, production is inflow and sales is outflow. Hypothesis is that sales (outflow) exceeds production (inflow), that is net flow  $< 0$  and as result inventory of finished goods (stock) decrease.  
A. Is the hypothesis consistent with law of market and does it explain the observed decreasing of finished goods.  
P. Use the model to see the effects of increasing production.  
I. For implementation policy we need to provide enough number of labor, capital and improve capacity.

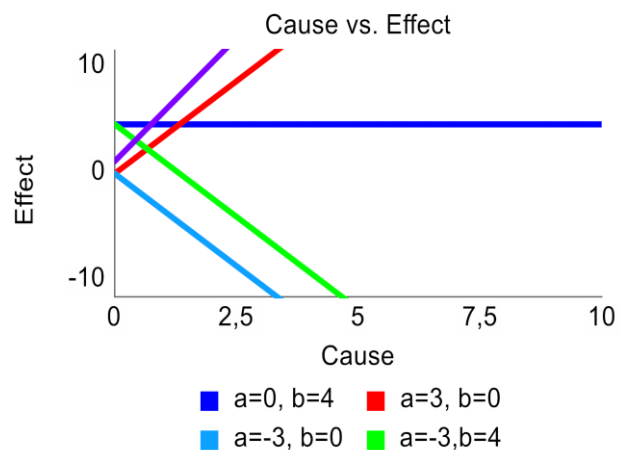
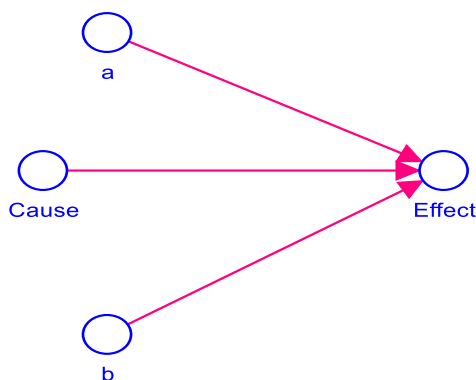
2.1. It's important to identify a reference mode before starting to analyze a problem, because when we observed problem behaviors it help us:

- to set a boundary for what should be included in your model;
- to set time horizon for the simulation model.

3.1. Below is an illustrations of linear instantaneous cause and effect in a SFD, which describes by mathematical definition :

$$Effect = b + a * Cause$$

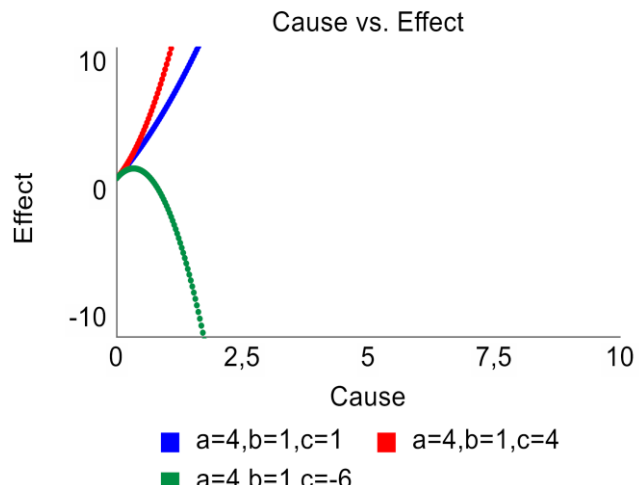
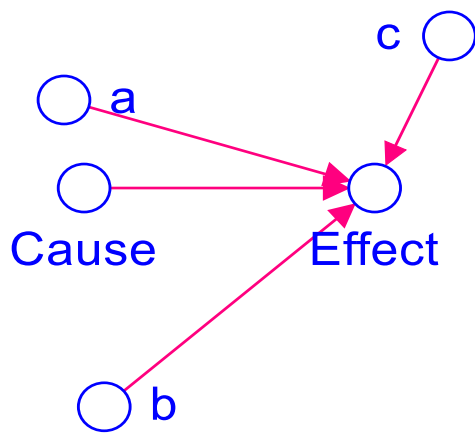
The linear cause and effect relationship can be portrayed as a straight line, below graph of possible relationship between cause and effect with fixed parameter a, b, c.



Below is an illustrations of nonlinear instantaneous cause and effect in a SFD, which describes by mathematical definition :

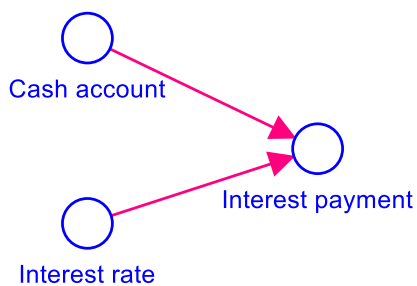
$$Effect = f(Cause)$$

The nonlinear cause and effect relationship can not be portrayed as a straight line, below graph of possible relationship between cause and effect with fixed parameter a, b, c.

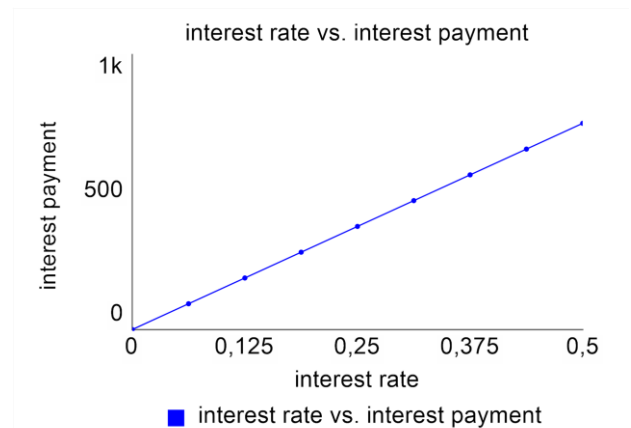


$$Effect = b + a * Cause + c * Cause * Cause$$

3.2. **Effect of interest rate on interest payments** can be represented by an instantaneous relationship



$$Interest\ payments = Cash\ account * Interest\ rate$$



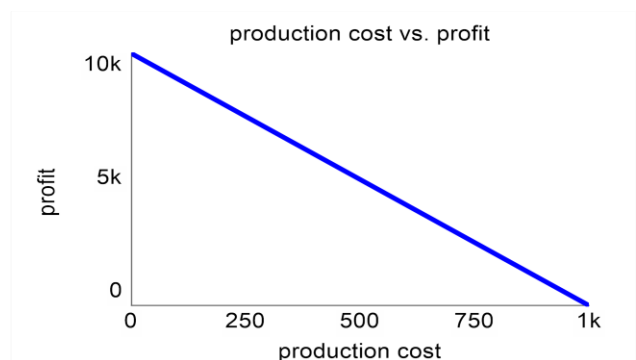
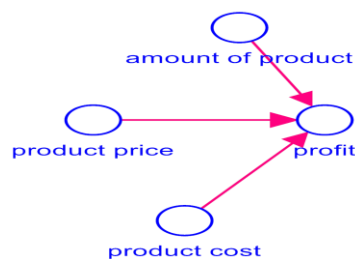
The relationship between interest rate and interest payment is linear because the higher the interest rate the more income on earned on cash accounts.

Interest rate: percentages per year (unitless per year because for example 20% = 0, 2)

Cash account: US Dollars

Interest payment: US Dollars per year.

**Effect of production costs on profits** can be represented by an instantaneous relationship



$$Profit = (product\ price - product\ cost) * amount\ of\ product$$

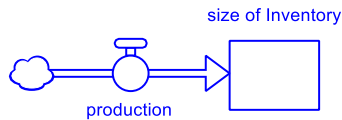
The relationship between interest rate and interest payment is decreases linearly because the higher production cost the less profit.

Amount of product: unitless;

Product price, product cost, profit : US Dollars.

**Effect of production on size of inventory** can be represented by an accumulation relationship.

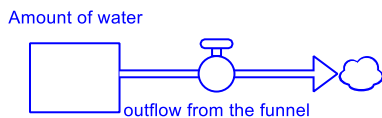
Production (inflow) and size of inventory (stock).



Production: products per hours. Inventory: products.

**Effect of amount of water in a funnel on the outflow from the funnel** can be represented by an accumulation relationship.

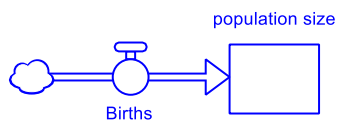
Amount of water (stock) and outflow from the funnel ( outflow).



Amount of water: liters. Outflow from funnel: liters per minute.

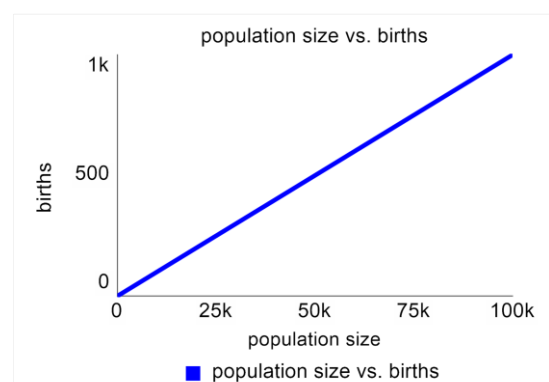
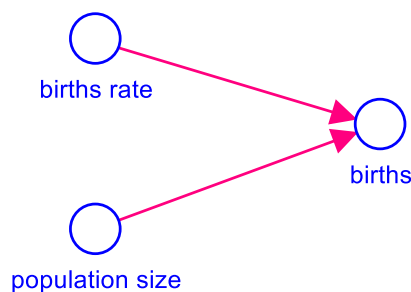
**Effect of births on population size** can be represented by an accumulation relationship.

Births (inflow) and population size (stock).



Population size: people. Births: people per months.

**Effect of population size on births** can be represented by an instantaneous relationship.



$$Births = Population\ size * births\ rate$$

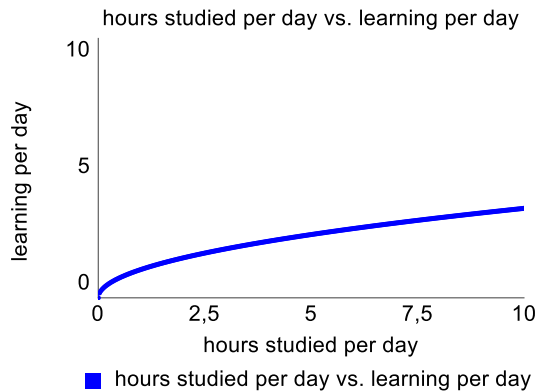
Births rate unit: percentages per year (unitless because for example 20%=0, 2)

People size unit: people.

Births unit: people per year.

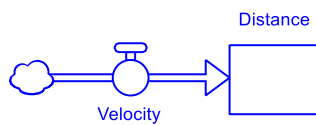
**Effect of hours studied per day on learning per day** can be represented by an instantaneous relationship.

The relationship between of hours studied per day and learning per day is nonlinear, because the more time a person spends on studying the less productivity is.



**Effect of velocity on distance travelled** can be represented by an accumulation relationship.

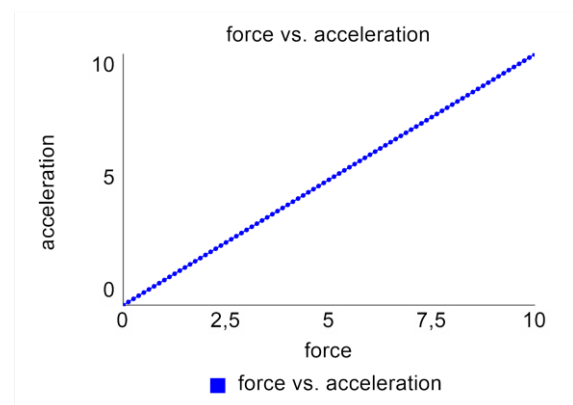
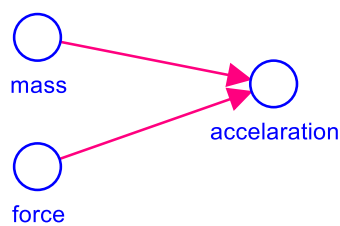
Velocity (inflow) and distance (stock).



Velocity: kilometers per hour.

Travelled distance: kilometers.

**Effect of force on acceleration** can be represented by an instantaneous relationship.



$$acceleration = force/mass$$

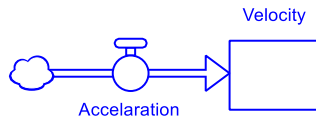
Force:  $1 \text{ H} = 1 \text{ (kilogram*meter)/(second*second)}$

Mass: kilogram

Acceleration:  $\text{meter}/(\text{second}*\text{second})$

**Effect of acceleration on velocity** can be represented by an accumulation relationship.

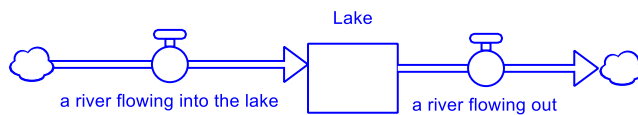
Acceleration (inflow) and velocity (stock).



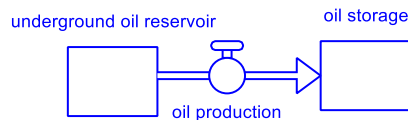
Acceleration: meter/(second\*second). Velocity : meter/ second.

4.1.

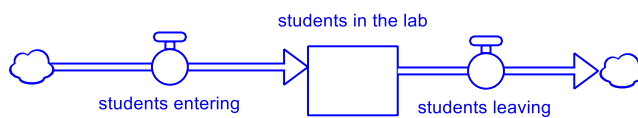
a) a lake, a river flowing into the lake and a river flowing out



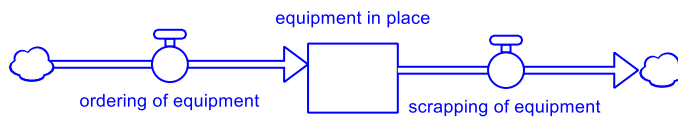
b) oil production, underground oil reservoir, oil storage



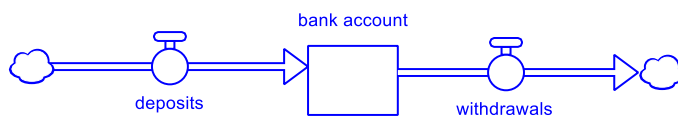
c) students in the lab, students entering, students leaving



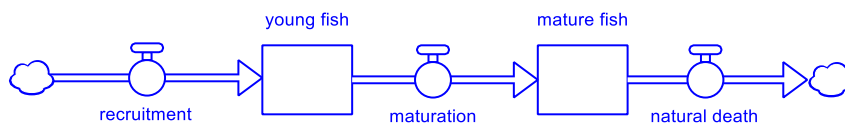
d) ordering of equipment, scrapping of equipment, equipment in place



e) withdrawals, bank account, deposits



f) mature fish, maturation, natural death, recruitment, young fish

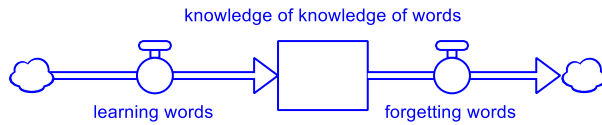


g) customers using a product and customers no longer using a product

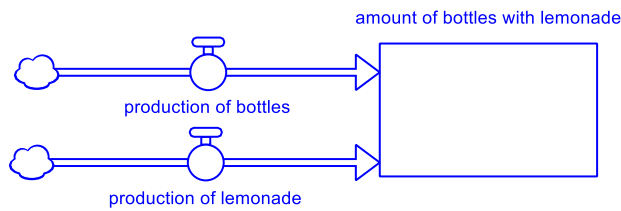
customers using a product



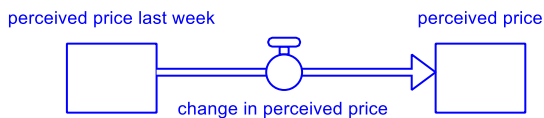
h) knowledge of words, learning words, forgetting words



i) production of bottles, production of lemonade, amount of bottles with lemonade



j) perceived price, perceived price last week, change in perceived price



b)

a) a lake : liters, cubic meters, gallons;

a river flowing into the lake and a river flowing out liters per minutes, liters per hours, cubic meters per minutes, cubic meters per hours, gallons per minutes, gallons per hour.

b) oil storage, underground oil reservoir : barrel;

oil production : barrel per minutes, barrel per hours.

c) students in the lab: people;

students entering, students leaving: people per hours, people per minutes.

d) equipment in place: units;

ordering of equipment, scrapping of equipment: units per hours, units per minutes.

e) deposits bank account: dollars ,euro;

withdrawals, deposits: dollars per hours, dollars per day.

f) mature fish, young fish: fish, unit;

maturation, natural death, recruitment: fishes per hours, fishes per day, units per hours, units per day

g) customers using a product: people;

customers no longer using a product: people per day, people per months.

h) knowledge of words: world, units;

learning words, forgetting words: worlds per hours, units of day.

i) amount of bottles with lemonade: bottles, units;

production of bottles, production of lemonade: units per hours, units per day, bottles per hours, bottles per day.

j) perceived price, perceived price last week: dollars ,euro

change in perceived price: dollars per hours, dollars per day.

4.2. a) For analysis does not matter what units we choose, for example, for a particular flow, since it does not affect the simulation of the model and calculations. One of the important thing to the analysis is to include all the important factors that affect the dynamics of the model . To determine which units to use in the model, we need to understand how quickly the changes occur in the model and if this occurs in short run or long run.

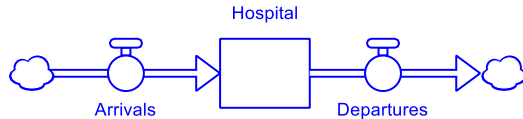
b) According to Euler method for integration:

$$\text{Stock}_t = \text{Stock}_{t-1} + DT * \text{Flow}, \text{Flow} = \text{Inflow} - \text{Outflow}$$

We have to measure all in- and outflows to all stocks in a model with the same time unit, because we cannot subtract outflow from inflow if they have different unit of measurement, as this is not correct.

$$\text{Stock}_t = \text{unit} + \text{time} * \left( \frac{\text{unit}}{\text{time}} - \frac{\text{unit}}{\text{time}} \right) = \text{unit}$$

4.3.



a) The most patient arrived in 07.01.2001.

b) The fewest patients arrived in 03.01.2001.

c) The most patients arrived in 13.01.2001.

d) The fewest patients arrived in the period from 31.12.2000 to 1.01.2001 and in 06.01.2001.

e) In period from 31.12.2000 to 8.01.2001 inflow exceeds outflow, so stock increases over this time, but from 8.01.2001 to 13.01.2001 outflow exceeds inflow, so stock decreases over this time. Therefore, the most patients in hospital in 8.01.2001.

f) Using previous considerations we have that the fewest patients in the hospital in 13.01.2001.